Endothermic and Exothermic Reactions Lab

Many chemical reactions give off energy. Chemical reactions that release energy are called exothermic reactions. Some chemical reactions absorb energy and are called endothermic reactions. You will study one exothermic and one endothermic reaction in this experiment and construct energy diagrams for each one.

In Part I, you will study the reaction between citric acid solution and baking soda. An equation for this reaction is:

$$H_3C_6H_5O_7(aq) + 3NaHCO_3(s) \longrightarrow 3CO_2(g) + 3H_2O(l) + Na_3C_6H_5O_7(aq)$$

In Part II, you will study the reaction between magnesium metal and hydrochloric acid. An equation for this reaction is:

$$Mg(s) + 2HCl(aq) \longrightarrow H_2(g) + MgCl_2(aq)$$

Another objective of this experiment is for you to become familiar with recording data over a period of time using LoggerPro. You will then take your data and graph it using Excel (or some other graphing program) to visually see how temperature can for each chemical reaction.

MATERIALS

IBM-compatible computer
Vernier Temperature Probe
Go! Link
Sodium Bicarbonate, $NaHCO_3$
Magnesium (Mg)
50-mL Graduated Cylinder
Styrofoam cup
Beaker
1.0 M Citric Acid, $H_3C_6H_5O_7$, solution
Balance
3.0 M Hydrochloric Acid, HCl, solution

Part 1. Citric Acid Reacting with Sodium Bicarbonate

Procedure

1. Obtain and wear safety goggles.

2. Place a Styrofoam cup into a 250-mL beaker as shown in Figure 1 below. Measure out about 30 mL of 1.0 M citric acid solution, record the exact volume, and then pour the solution into the Styrofoam cup.

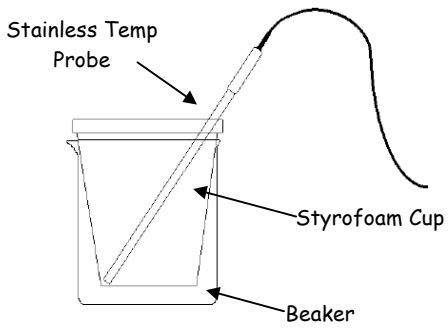

Figure 1

3. Connect the direct temperature probe to the GO! Link adapter, and plug it into a USB port on the mini. Open LoggerPro on the computer.

4. LoggerPro should recognize the temp probe right away and begin to display a temperature in the bottom left corner of the screen. If it does not, click on the Go! button in the top right hand corner of the screen. From the list of probes select the TEMPERATURE probe from the menu.

5. Now set up the data collection parameters. Click on the icon and select "Time Based" from the data collection mode drop down box. For the "Length" enter 300 seconds making sure the probe is taking a sample every second. Now click done.

6. Place the temperature probe into the citric acid solution as also shown in figure 1 above.

7. Mass out about 10.000 g of sodium bicarbonate.

8. When everything is ready, click the button to begin data collection. After about 20 seconds have elapsed, add the baking soda to the citric acid solution. Gently stir the solution with the temperature probe to ensure good mixing. Be sure the to keep the tip of the probe suspended in the middle of the liquid in the cup. A real-time graph of temperature vs. time will be displayed on the screen during data collection and your data will appear in the data table to the left of your graph in red type. When data collection stops after 5 minutes, data collection will automatically stop and you will see your

graph displayed on the screen. (Note: If the reaction ends before the 5 minutes are up, you can press  to stop the data collection)

9. Dispose of the reaction products by rinsing them down the drain with a lot of water. Rinse the temperature probe and cup with a lot of water. Your data will be stored in the program for later use.

Part 2. Magnesium Reacting with Hydrochloric Acid

Procedure

1. Measure out 30.0 mL of the 3.0 M HCl solution into the Styrofoam cup. Record the volume used. Place the temperature probe into the HCl solution.

2. Obtain a 10.0 cm piece of magnesium metal. Measure and record the mass of Mg used. Tear the Mg into small pieces to allow more surface area for the reaction to take place.

3. Begin to collect data as in the previous experiment. Make sure you choose to "Store Latest Run" so you do not lose your previous data (it will now be in blue). The temperature probe must be in the HCl solution for at least 45 seconds before doing the next step. Add the Mg to the HCl solution. Gently stir the solution with the temperature probe to ensure good mixing. Caution: Do not breathe the vapors. Data collection will automatically stop after data has been collected for a total of 5 minutes.
4. Dispose of the reaction products by pouring them in the waste container. Rinse the temperature probe with tap water.

Transferring Data Excel.

It is really easy to transfer the data from LoggerPro to Excel. Simply open up an Excel spread sheet and copy and paste your data from LoggerPro. You may need to resize the data table in LoggerPro to see all your data, but you can select all your data (Ctrl A) and copy it directly from program to program Then graphs can be made using Excel. Make sure you use a scatter plot from graphing options. (The LoggerPro graphs are also fine to use, but Excel will be used later for other data that is collected so it is always good to have a refresher

Calculations

1. Prepare both properly labeled graphs using graphing software and secure them in your lab notebook. Make sure to size them to fit on a page neatly.

2. Based on the temperature changes and the specific heat of water, calculate the heat released or absorbed in the chemical reactions.

3. Determine what the limiting reactant is in each reaction.

4. Based on the limiting reactants, calculate the amount of energy that would be released per mole in each reaction.

5. Write thermochemical equations for each reaction.

Conclusions and Questions

1. How fast was the temperature change for each reaction? Explain.

2. Explain the ΔG and ΔS for each reaction. Why is the endothermic reaction happening spontaneously?

3. Why can we not measure heat directly?

4. What is activation energy? Why do we not need to worry about the activation energy for either of these reactions?

5. Describe some possible sources of where energy can be lost during this experiment.